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# (54) LOAD FACTOR SAFETY MECHANISM

(71) We, VEB WEIMER-KOMBINAT, a corporation organised under the laws of East Germany, of 4 Buttelstedter Strasse, Weimar, Germany, do hereby declare the inventon, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a crane or the like device, such as a loader or excavator having a safety mechanism for limiting the load moment particularly in such equipment provided with a two-membered or multi-membered boom which, in the absence of a lifting mechanism, moves the load by displacing the individual sections of the boom.

According to the present invention there is provided a crane or the like device having a plurality of operating modes including as one operating mode the raising and lowering of a load which, in use, is suspended from a boom structure, there being provided for each operating mode:

(a) hydraulic means;
(b) a hydraulically operated control valve for controlling the flow of oil to said hydraulic drive means; and
(c) a solenoid operated disconnection valve in the hydraulic circuit of said control valve,

the device also being provided with:

(d) means for detecting when the load moment exceeds a first predetermined limit;
(e) means for detecting when the load moment exceeds a second higher predetermined limit;
(f) means for reducing the maximum speed of operation of each said hydraulic drive means upon detection of a load moment in excess of said first predetermined limit;
(g) disconnection means for operating each solenoid operated disconnection valve upon detection of a load moment in excess of said second predetermined limit whereby operation of each operating mode is blocked; and
(h) overriding means for overriding said disconnection means to allow operation of the hydraulic drive means associated with the operating mode for raising and lowering the load, in a load moment reducing direction when the load moment exceeds said second predetermined limit,

wherein said overriding means includes:

(i) a cam disc secured to the boom; and
(j) a switch operated by said cam disc in dependence upon the position of the boom structure.

Preferably, the disconnection valves operate when the solenoid has been energised to release the flow of oil from direction control valves to the valve members of the control valves of the hydraulic drive means. In the event of overloading, when the solenoid has ceased to be energised, the flow of oil is shut off and the valve members of the control valves direct the oil to an oil return line.

The control valve is preferably of the type operating in response to a hydraulic pressure differential between two hydraulic fluid supply lines fed with oil from a direction control valve. Preferably the disconnection valves are arranged in pairs, one in each supply line. Advantageously the means for reducing the maximum operating speed of each hydraulic drive means comprises means for reducing the pressure in the hydraulic circuit of each control valve thereby to limit the flow of oil to each hydraulic drive means.

In order to allow for changes in the spatial arrangement or rig condition of the boom structure it is necessary that the switch over point of the cam disc operated switch in relation to the spatial position of the boom structure be altered in order to ensure that, upon overloading, operation of the load raising and lowering hydraulic drive means is only allowed in a load moment reducing direction. This may be achieved by adjusting the cam disc relative to the boom structure or by providing a plurality of cam disc operated switches and a further switch for selecting the cam disc operated switch appropriate to the spatial arrangement of the boom structure.

For the purpose of controlling the process of disconnection in terms of time a throttle valve is connected in the return line of the disconnection valves.

Constructions according to the invention should improve the balance of cranes, loaders and excavators of elevated operating rates and correspondingly great dynamic loading as a result of reducing the operating rate of the drive mechanisms in the range of heavy loading by reducing the flow of oil to the individual drive mechanisms.

The present invention enables the construction of hydraulically driven cranes, loaders and excavators having multi-membered booms where the safety mechanism permits optimal balancing of the equipment, precludes the crane, loader or excavator tipping over and prevents overloading of specific structural elements.

Furthermore, it enables the improvement of the balance of cranes, loaders and excavators operating at fast speeds by a reduction of the additional dynamic loading which occurs upon disconnection.

A constructional embodiment of the invention will now be explained purely by way of example with reference to the accompanying drawing in which:

Figure 1 shows a boom structure of a crane according to the invention.

Figures 2, 2A and 2B show the hydraulic circuits for the drive mechanisms of various operating modes.

Figure 3 shows the electric circuit.

The boom structure shown in Figure 1 includes a boom section 6 pivoted to an upper carrying chassis 5 of a crane or the like, and carrying a dipper arm 7. Piston and cylinder devices 4 and 18 drive the boom section 6 and the dipper arm 7 respectively.

The load factor safety mechanism comprises a data receiver in the form of a rocker arm 1 and a transducer 2. The transducer 2 feeds an electrical signal dependent upon a component of force of the boom cylinder 4 to a disconnection circuit 3 (Figure 3). To this end, the boom cylinder is mounted on the rocker arm 1 on the upper carrying chassis 5. The strength of the input signal is proportional to the loading on the crane, regardless of the position of the boom section 6 and the dipper arm 7.

The disconnection circuit 3 is of known construction and of the type having an output 8 which drops to zero when a predetermined input limit is reached, in this case when a predetermined load limit is reached.

Referring to Figure 2, the piston and cylinder device 4 is provided with oil from a pump 131 via a line valve 15. The later is in turn controlled hydraulically with oil supplied from a pump 32 via a direction control valve 16 and disconnection valves 14 and 33 operated by electromagnets 24 and 25 respectively. A throttle valve 17 for reducing the dynamic forces developed when the disconnection valves 14 and 33 are closed, is connected in the return line common to the disconnection valves.

Hydraulic pressure in the line valve operating circuit is controlled by a pressure limiting valve 29 connected between the pump 32 and the direction control valve 16. This valve is set to nominal control pressure. A control valve 28 operated by a solenoid 27 enables the pressure in the line valve operating circuit to be reduced to a pressure determined by a second pressure limiting valve 30 for purposes which will become clear hereinafter. A throttle valve 31 is provided ahead of the control valve 28 for smoothing out the effect of an abrupt variation in control pressure.

Figure 2A shows a similar hydraulic circuit associated with the dipper arm piston and cylinder device 18. As compared with Figure 2, in Figure 2A like features are indicated by like reference numerals provided with a single prime. The disconnection valves 14′ and 33′ are operated by electromagnets 21 and 23 respectively.

Figure 2B shows a similar hydraulic circuit for another piston and cylinder device 34, not shown in Figure 1, associated with some other movement of the crane, such as propulsion or rotation. As compared with Figure 2, in Figure 2B like features are indicated by like reference numbers provided with a double prime. The disconnection valves 14″ and 33″ are operated by electromagnets 20 and 22 respectively.

Referring to Figure 3, the output of the disconnection circuit 3 is connected to a relay 19. The position of the relay shown in Figure 3 is that when the output of the disconnection circuit is zero, i.e. when the load limit has been exceeded. When the output of the disconnection circuit is live, the relay is operated and a source of current is connected directly to each of the solenoids 20 to 25.

The embodiment as so far described operates as follows. Provided the load sensed by the transducer 2 is below the predetermined limit, the solenoids 20 to 25 are all energised. Referring to Figure 2, it will be seen that when the solenoids 24 and 25 are energised, the disconnection valves 14 and 33 are open as shown, and oil can be directed to the line valve 15 in either direction according to the position of the direction control valve 16. Accordingly the boom piston and cylinder device 4 can be operated to either raise or lower the boom as desired. Referring to Figures 2A and 2B it will be seen that other movements of the crane can also be carried out freely.

However, when the load sensed by the transducer 2 exceds the predetermined limit, the relay 19 reverts to the position shown. In this position none of the solenoids 20 to 23 is energised. Referring to Figure 2A, it will be seen that when solenoids 21 and 23 are de-energised the upper compartments of the disconnection valves 14', 33' become operative and no oil can be directed to the line valve 15' which, as a consequence of its return springs, therefore adopts the position shown where the piston and cylinder device 18 cannot be operated and oil flows via the throttle valve 17 into the return line. Referring to Figure 2B it will be seen that other movements of the crane are also prevented.

However, the circuitry of the solenoids 24 and 25 associated with the boom piston and cylinder device 4, includes a switch 11 which connects a source of current to one or other of the solenoids 24 and 25 when the relay is in the off position shown.

The switch 11 is operated by a cam disc 10 secured to the boom section 6 at its point of articulation 9 (see Figure 1) when the boom section 6 performs a luffing movement. The cam disc 10 is so adjusted that the switch 11 switches over when the point of suspension 12 of the load has reached the same level as the point of articulation 9 of the boom. Since an additional degree of $\varphi 2$ results from the dipper arm 7 but the point of change-over of the switch 11 depends only on the angle $\varphi 1$, the thus produced switching error can at the worst result in an alteration $\Delta 1$ of the radius of travel. By uniformly distributing this error over the positive and negative ranges it can be maintained at a very low value.

When varying the boom rig it generally becomes necessary to correct the switching-over point of the switch 11. This is realised by rotating the cam disc 10 with respect to the boom section 6 or by means of a series of staggered switches 11, each such switch 11 being associated with one boom rig. As is shown in Figure 3 the switch 11 corresponding to the respective boom rig is then manually selected by means of a variant switch 13.

When the point of suspension 12 of the load is below the level of the point of articulation 9 of the boom, (i.e. when $\varphi 1 < 0$) the position of the switch 11 is such that the electromagnet 24 is energised and the electromagnet 25 is de-energised. Thus, referring to Figure 2 it will be seen that in this situation, the left hand compartment of the line valve 15 cannot become operative, no matter what the position of the direction control valve 16. As a consequence, movement of the boom piston and cylinder device 4 corresponding to an upward movement of the boom is prevented. Similarly when the point of suspension 12 is above the level of the point of articulation 9, (i.e. when $\varphi 1 > 0$) movement of the boom in a downward direction is prevented. Thus, after the occurrence of overloading the multi-membered boom can be repositioned in a radius of travel reducing direction only. Cranes loaders and excavators with hydraulically actuated boom sections and without rope lifting tackle are remarkable for elevated operating speeds. Major additional dynamic loads develop in conjunction with brief periods of acceleration and deceleration and must be allowed for in load factor safety mechanism by correspondingly great safety margins when the disconnected loading is fixed. In order to improve the balance of the crane or excavator the load factor safety mechanism is equipped with the disconnection device 3 whereby in addition to the disconnection signal an anticipatory switching signal is produced in such a form that before the maximum permissible load factor is reached and the thus existing voltage drop at the output 8 of the disconnection device 3, the voltage also drops at the second output 26 upon a specific loading of the crane.

The output 26 of the disconnection circuit 3 energises the solenoids 27, 27', 27'', so that the valves 28, 28' and 28'' are normally shut, but when this output drops to zero on reaching the predetermined "anticipatory" load level, the valves 28, 28' and 28'' each adopt an open position on account of their valve return springs The pressure in the line valve control circuits is now determined not by the pressure control valves 29, 29' and 29'' but is set at a lower level by the pressure control valves 30, 30' and 30''. This lower pressure is no longer sufficient for the line valve 14 etc. to be fully open and thus by means of the pressure limiting valves 30, 30' and 30'' the operating speed of the piston and cylinder drive mechanisms 4, 18 and 34 is reduced in the region between the load reaching the "anticipatory" load level and the "disconnection" load level.

In this region the additional dynamic loads are therefore reduced. In this manner, when the crane is heavily loaded, the load can only be moved at a reduced speed. The throttle valves 31, 37', 31" disposed between the pressure control valves reduce the effects of sudden changes in control pressure.

WHAT WE CLAIM IS:—

1. A crane or the like device having a plurality of operating modes including as one operating mode the raising and lowering of a load which, in use, is suspended from a boom structure, there being provided for each operating mode:

(a) hydraulic drive means;
(b) a hydraulically operated control valve for controlling the flow of oil to said hydraulic drive means; and
(c) a solenoid operated disconnection valve in the hydraulic circuit of said control valve,

the device also being provided with:

(d) means for detecting when the load moment exceeds a second higher limit;
(e) means for detecting when the load moment exceeds a second hifher predetermined limit;
(f) means for reducing the maximum speed of operation of each said hydraulic drive means upon detection of a load moment in excess of said first predetermined limit;
(g) disconnection means for operating each solenoid operated disconnection valve upon detection of a load moment in excess of said second predetermined limit whereby operation of each operating mode is blocked; and
(h) overriding means for overriding said disconnection means to allow operation of the hydraulic drive means associated with the operating mode for raising and lowering the load, in a load moment reducing direction when the load moment exceeds said second predetermined limit,

wherein said overriding means includes:

(i) a cam disc secured to the boom; and
(j) a switch operated by said cam disc in dependence upon the position of the boom structure.

2. A crane or the like device as claimed in claim 1 wherein said overriding means includes a plurality of said cam disc operated switches selectable according to the spatial arrangement of the boom structure.

3. A crane or the like device as claimed in claim 2 wherein a selecting switch is provided for selecting the cam disc operated switch appropriate to the spatial arrangement of the boom structure.

4. A crane or the like device as claimed in claim 1 wherein said cam disc is adjustable relative to the boom structure.

5. A crane or the like device as claimed in any preceding claim wherein a throttle valve is disposed in the oil return flow line of each control valve.

6. A crane or the like device as claimed in any preceding claim wherein each said means for reducing the maximum operating speed of each hydraulic drive means comprises means for reducing the pressure in the hydraulic circuit of each control valve thereby to limit the flow of oil to each hydraulic drive means.

7. A crane or the like device substantially as herein described with reference to and as illustrated in the accompanying drawings.

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1403046 COMPLETE SPECIFICATION
5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

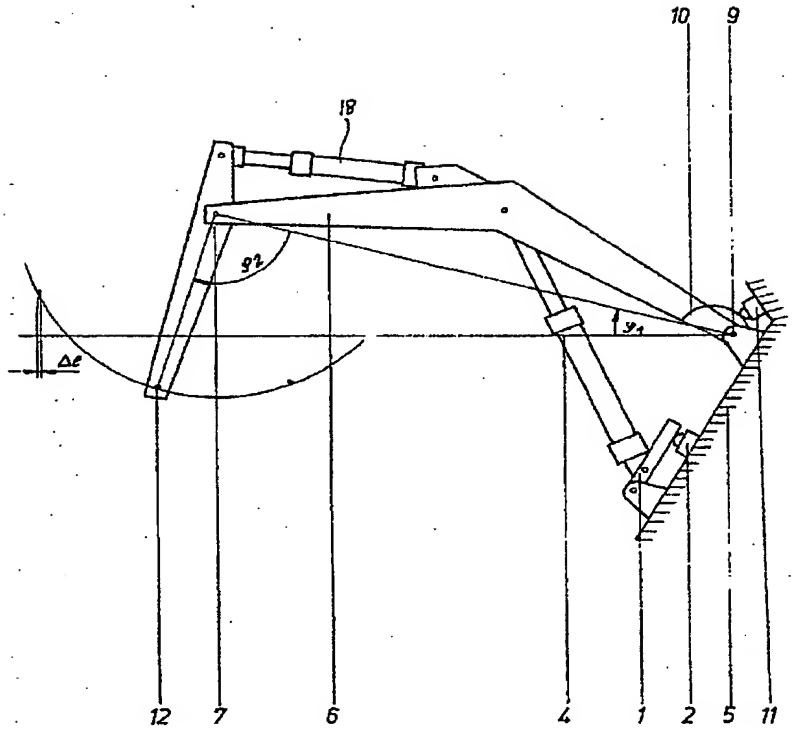


*Fig 1*

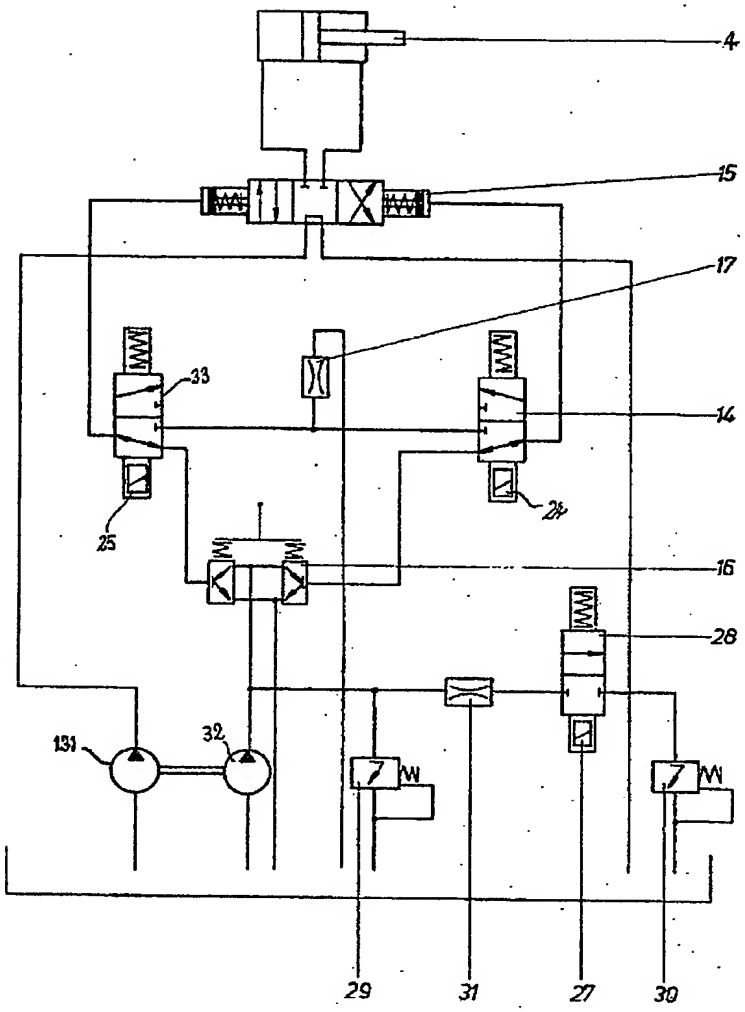


*Fig 2*

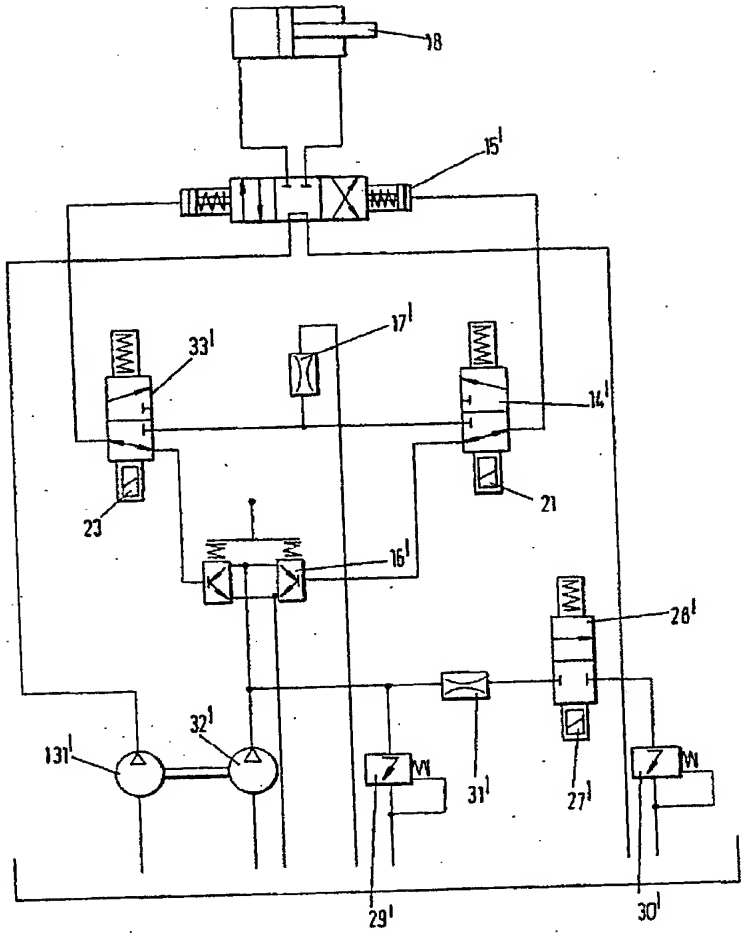


FIG. 2A

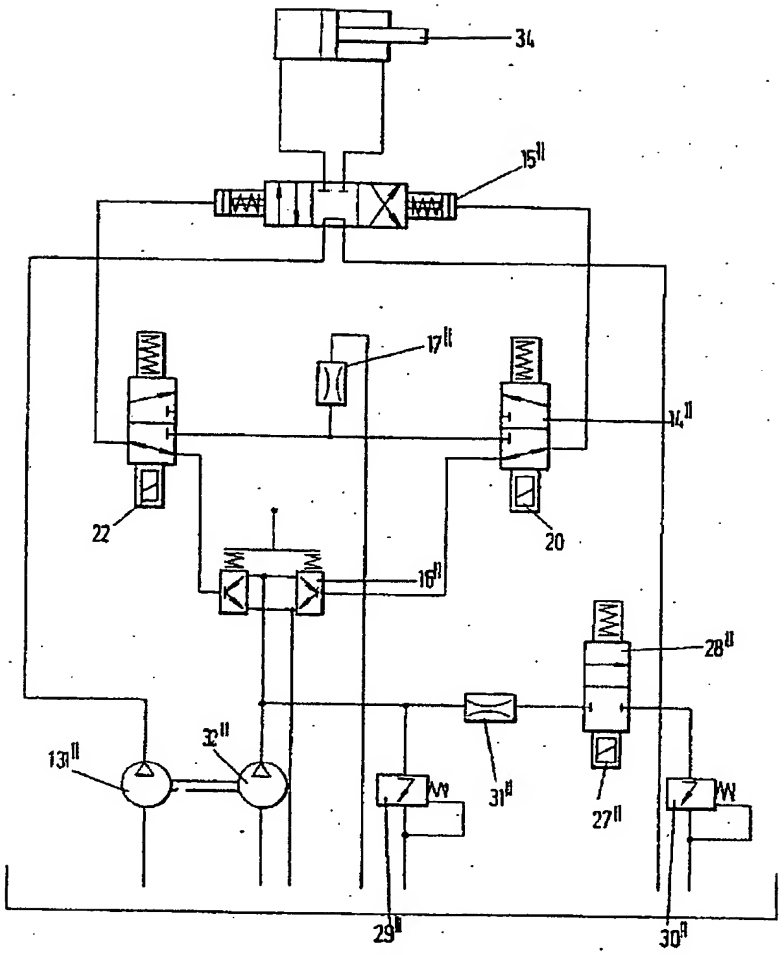


FIG. 2B

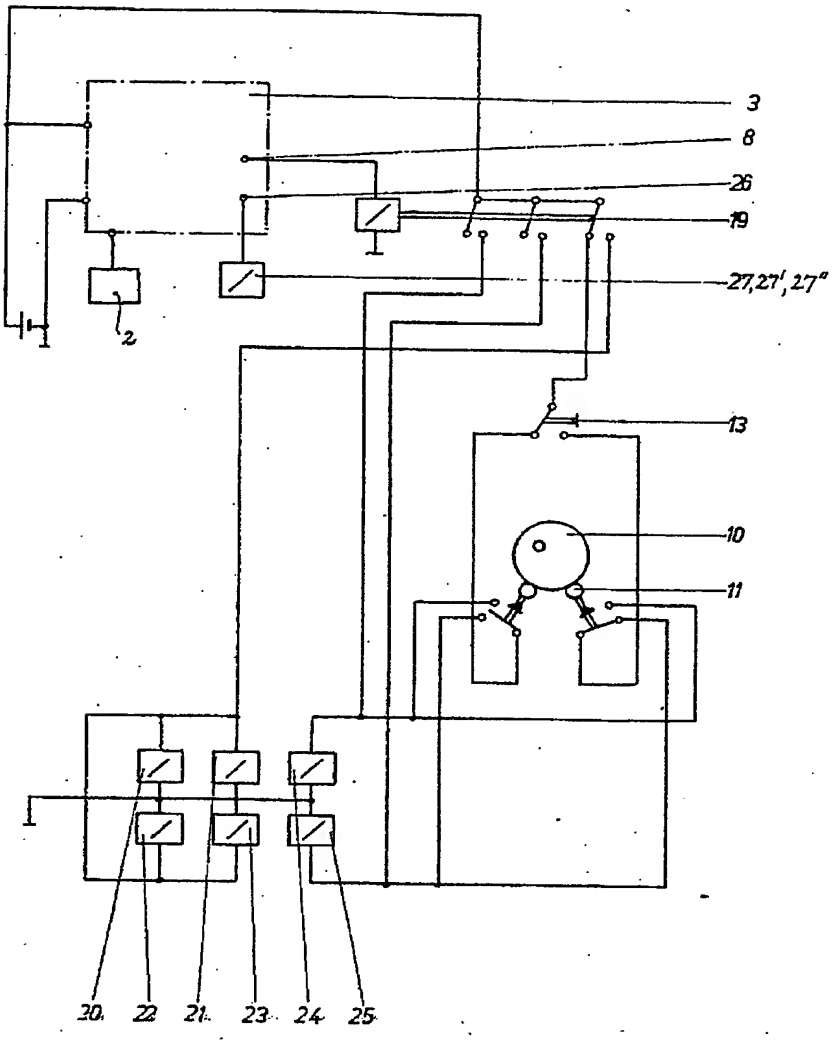


Fig 3